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BIOACCUMULATION OF SODIUM ALKYL SULFATE, ZINC CHLORIDE AND THEIR MIXTURE IN YOUNG GOBY, PROTERORHINUS MARMORATUS PALL*

S. TOPÇUOĞLU - E. BİROL

Çekmece Nuclear Research and Training Center,
P.O. Box 1. Havaalanı - Istanbul

ABSTRACT

The bioaccumulation of labelled surfactant, ^{35}S-labelled sodium lauryl sulfate and ^{65}Zn-labelled zinc chloride, was investigated both as a mixture and alone by themselves in young goby. The concentration factor of 7.15 was calculated for the surfactant in the whole-body fish and there was no effect of zinc chloride on this bioaccumulation process. Biological half-life of the surfactant was around 35 hours. The effects of surfactants on the zinc accumulation were also followed under the same conditions. The results indicated that the sodium lauryl sulfate had no effect on the accumulation of zinc, however, the other surfactant, linear alkylbenzene sulfonate, caused a significant increase in the zinc accumulation in compared with the control group, during the uptake period.

ÖZET

Denizlerin veya geniş anlamda suların kirlenmesinde radyoaktif veya stabil çinko ile deterjanların önemi çok büyüktür. Damgalı deterjan ve çinko kullanarak nükleer tekniklerle yürütülen bu araştırmada, ^{35}S damgalı sodyum loril sülfatın balık yavrularındaki konsantrasyon faktörü 7.15 biyolojik yarı-ömrü yaklaşık 35 saat bulunmuştur. Bunun yanında hem deterjan ve hem de çinkonun bulunduğu ortamda, bu deterjan yüzey aktif maddesinin yani sodyum loril sülfatın birikimi fark göstermemiştir. Çinko birikimi üzerine sodyum loril sülfatın etki etmediği de diğer bir deneyde görülmüştür. Buna karşılık deterjanın diğer bir yüzey aktif maddesi olan, lineer alkilbenzen sülfonat (Ülkemizde de kullanılan) çinko birikimini kontrola göre anlamlı olarak arttırmıştır.

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INTRODUCTION

Linear alkylbenzene sulfonate (LAS) is a major anionic surfactant material used in large volumes by detergent industry. This product has the property of readily biodegradable in waste-water than the old surfactant, branched alkylbenzene sulfonate (ABS) /1,2/. Sodium alkyl sulfate (AS) are also used as raw materials for detergents, which has better biodegradability than the LAS. For this reason, AS may be a good alternative to LAS when the pollution in the marine environment is considered /3,4/.

The effects of detergents or surfactants on marine organism have studied by many researchers. In many studies, LC_{50} or physiological effects have been used for the indication of acute toxicity in marine organism /5,6/. At the same time, the acute toxicity was investigated by using biokinetic method such as the accumulation and loss rates of detergents in living materials /3,8/. On the other hand in order to investigate the chronic effects, factors such as retardation of growth, feeding behaviour and inhibition of chmoreceptor organs have been examined in the same organisms /7/.

The trace element zinc is known to occur in high concentrations in fish relative to its level in water. The radioactive isotope of zinc (^{65}Zn) is produced as a neutron activation product of nuclear power industries. As a result of the operation of Hanford nuclear plant on the Columbia river, ^{65}Zn is found to be the most conspicuous γ emitter in fish /9/. Many laboratory and field experiments have been devoted to the kinetics of accumulation, loss and distribution of ^{65}Zn by fish /10 - 13/.

All aquatic organisms especially the marine originated ones, are exposed to the mixtures of many pollutants in nature. It is therefore, important to establish which pollutants interfere with each other and the way they intensify and reduce their effects on the organisms involved. Until now, few studies have been concerned with pollutant interactions in the marine environment. Gold fish in tanks once exposed to LAS detergents at a 4 ppm concentrations for 2-months period were found to be susceptible to DDT when compared with fish not living in the presence of LAS /14/. Majori et al., /15/ reported that the effect of the combination of detergent and lead showed an enhancement in the lead uptake by organisms. Brown et al.,

/16/ found that fish acclimated to zinc did not acquire resistance to zinc poisoning in the presence of a detergent.

In this study the bioaccumulation of the labelled detergent, (^{35}S-AS), with and without the presence of $ZnCl_2$, and of labelled $^{65}ZnCl_2$ alone and of its mixture with AS and LAS have been investigated.

EXPERIMENTAL

The young goby, Proterorhinus marmoratus PALL., was collected from the Küçük Çekmece Lagoon, brackish water. Similar sized animals were selected and they were acclimated to laboratory conditions for 10 days before the experiment. During the acclimatization period they were fed by Gammarus olivii and feeding was stopped 2 or 3 days before the experiment. No food was given during the experiment. The lagoon water used in the bioaccumulation experiments was previously filtered through cotton filter to remove particulate material. During the experiment the salinity and temperature of the water were 7.21 ‰ S and 15 ± 1°C respectively.

In our present study, the experiments were performed in two series. In one of the series the fish were divided into two groups whereas in the other series they were divided into three groups during the bioaccumulation period. Each group consisted of 30 animals and was kept in the experimental basin containing 4 liter lagoon water. In the first series 1 µCi (37 kBq)/liter ^{35}S-labelled sodium lauryl sulfate which is a component of sodium alkylsulfate together with 4 ppm unlabelled sodium laurly sulfate was added into each of the two basins. One group of fish within this serie was also exposed to 4 ppm $ZnCl_2$. In the second series, 1 µCi (37 kBq)/liter ^{65}Zn-labelled zinc chloride with 4 ppm $ZnCl_2$ was added into each of the three basins. Two groups of fish within this series were also exposed to 4 ppm AS or 4 ppm LAS. During the bioaccumulation period, water in the basins were changed once in every two days in order to keep both of the surfactant solution and labelled materials at constant level in the experiments and to avoid the possible effects of biodegradation of substances.

The radioactivity of ^{65}Zn in fish was counted as previously descibed /17/.

In order to determine the amount of ^{35}S accumulated in fish, organisms were first washed with clean lagoon

water. Then they were homogenised in 4 ml water and samples of 0.2 ml from each homogenate were transferred to the measuring vials. In the vials these samples were mixed with 9.8 ml Insta-Gel scintillation solution and subsequently these samples were counted on Packard Liquid Scintillation Counter using the 0.167 MeV beta emission of ^{35}S. 0.2 ml water samples taken from basins were also counted in the same manner.

RESULTS AND DISCUSSION

The results of the bioaccumulation of ^{35}S-AS in goby with and without the presence of $ZnCl_2$ are shown in Fig 1. The concentration factor of 7.15 at equilibrium was calculated for the surfactant in the whole-body of fish and no effect of $ZnCl_2$ has been observed on this bioaccumulation process. The results may be expressed as a linear differential equation with constant coefficient:

$$C_t = C_{ss} (1-e^{-kt})$$

where C_t = Concentration factor

$$\left(\frac{\text{cpm mg}^{-1} \text{ wet weight of animal}}{\text{cpm ml}^{-1} \quad \text{lagoon water}} \right)$$

at time t (hours), C_{ss} = Concentration factor at steady state, and k = Outward flux constant (biological loss constant) for ^{35}S-AS, ($k = 0.699/T_{1/2}$ where $T_{1/2}$ is biological half-life). The values of these parameters for one compartment were obtained by fitting a curve to the plotted means of values obtained for 4 individuals (for each counting time) from hour 0 to hour 240, using the method of least-squares. The fitted curve yielded the equation.

$$C_t = 7.15 \ (1-e^{-0.02t}).$$

The biological half-life of ^{35}S-AS was calculated to be 34.65 hours.

Wahabayashi et al /4/ found that the concentration factor of ^{35}S-AS in whole-body carp fish was 4. The difference between our and their results is probably due to the differences of species, ages of fish and also water used in the experiments. On the other hand, the concentration factor of ^{35}S-LAS was found higher

than ^{35}S-AS in the same report. This shows that the concentration factors are effected by the molecular structure of a surfactant. And it also shows that the elimination rate of ^{35}S-LAS is slower than that of ^{35}S-AS. In our result, the biological half-life for ^{35}S-AS during the uptake period was faster than that found in carp fish. However, Wakabayashi et al /4/ calculated the elimination rate of ^{35}S-AS from the loss period.

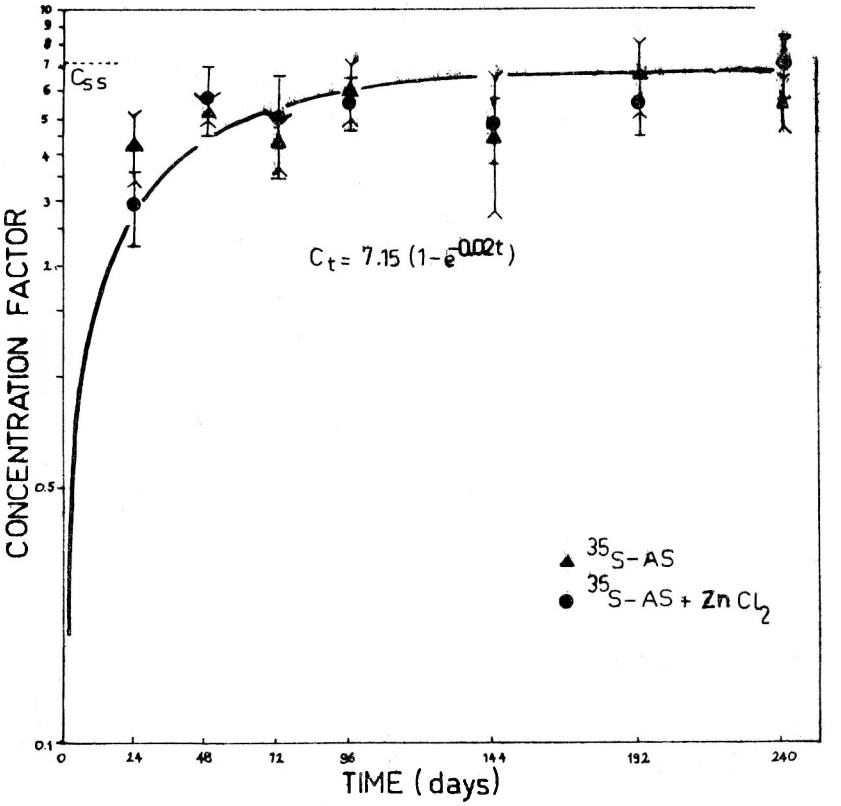


Fig. 1. Proterorhinus marmoratus. Accumulation of detergent with and without the presence of Zinc. Vertical bars represent ± one standard deviations. Fish averaged 0.57 ± 0.12 g wet weight.

The effects of the surfactants on the bioaccumulation of zinc in the second series are shown in Fig 2. The results indicated that the AS had no effect on the accumulation of zinc, however, the other surfactant, LAS caused a significant (we used the 0.05 level as a criterion of significance) increase in the zinc accumulation when compared with the control group, during the uptake period. For the carp fish exposed to ^{35}S-LAS for 2 hours, the highest concentration (40 times that of the ambient water) was found in gills, but the concentration of ^{35}S-AS in gills was only about three times that of the ambient water /3/. Tomiyama /18/ and Granama and Kollberg /19/ showed that high levels of surfactant were found in gills when fish were exposed to lethal concentration of the surfactants.

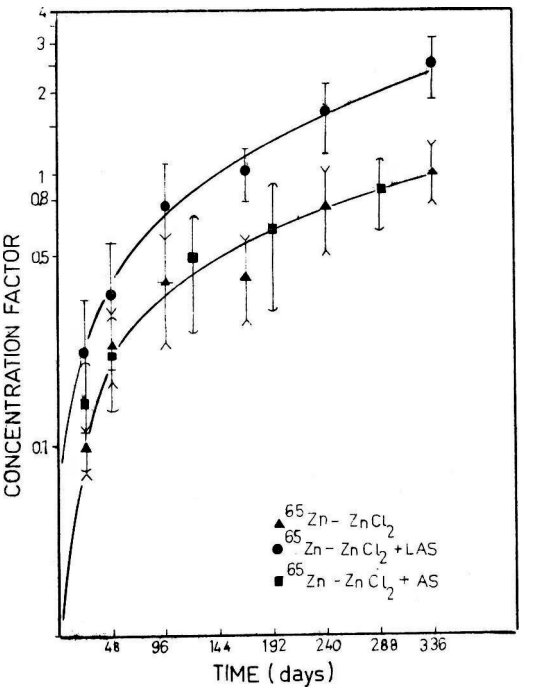


Fig. 2. Proterorhinus marmoratus. Accumulation of zinc with and without the presence of AS and LAS detergents. Vertical bars represent ± one standard deviations. Fish averaged 0.61 ± 0.15 g. wet weight.

On the other hand, the gill plays an important role as the site of accumulation for ^{65}Zn from water pathway /20,21/. Abel /7/ has reported that the most obvious acute toxic damage was observed on the gill surface. One of the biological responses of fish to detergents is the thickening of the gill epithelium which influences the rate of respiration /22/. These observed effects on the gill may damage the regulatory system and consequently the fish will take high levels of zinc when exposed to 4 ppm LAS detergent.

From data obtained with the young goby, it can be said that AS detergent will be environmentally a fairly good alternative to LAS because its accumulation on fish is minor and it has a short biological half-life and also has no effect on the accumulation of zinc.

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